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Best Practices for Planning and Executing Complex Brownfield Outages

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ABSTRACT

This paper will explore the Best Practices in terms of both planning and executing challenging brownfield outages on existing constrained production facilities where the outage duration and start-up performance are critical to the company's bottom line. The paper will focus on early planning and risk identification while maximizing pre-outage scopes of work to minimize outage risk. Emphasis will be placed on outage management processes and tools to ensure effective communication and progressing to enable the team to understand and manage to critical path activities and minimize unknown unknowns.

INTRODUCTION

"Brownfield" projects, in which new equipment is installed on high production operating units requiring a shutdown outage are arguably the most challenging projects to execute. Despite lots of planning, outages can extend, or start-up and production ramp-up may be slower than desired.

Existing facility process and utility documents and drawings can be quite old and missing, or not contain various modifications made over the years. Interactions between contractor crafts themselves, along with plant operations and maintenance must be very well coordinated. Therefore, a project like this must be treated much differently than a typical "green field" project. A project like this, where days of lost production can easily equate to millions of dollars, require a completely different level of planning and intensity. This paper focuses on the outage planning practices used successfully on several recent outages by the authors.

SAFETY PLANNING AND MANAGEMENT

Safety First, should always be the number one priority on any project. These brownfield projects often have additional factors and challenges that must be considered, particularly, working around an operating facility and often in tight areas.

Safety as a Value

To ensure safety is prioritized by all parties involved in the project and outage, upper management needs to create a culture where safety is communicated as the number one priority. If the impression by the craft is that safety is just "word of mouth" or "company policy" a true value of the owner, then corners will get cut to get work done faster or easier. Another practice that has proven impactful is for senior plant management to meet with the contractor's craft workers in person to ensure the culture is communicated and expectations are set.

The use of standard safety practices such as a Project Safety Management Plan, JHAs, Pre-task Plans, All Hands Meetings and Safety Observations should be used. These documents should be prepared well before construction begins and be part of the overall Safety Management Plan.

Commons Hazards and Risks
As the work (pre-outage and outage) will take place in an existing operating facility, craft personnel need to be made aware of specific operating area hazards which can include, but are not limited to:

- Overhead Cranes / Suspended loads
- Molten / Hot Metal
- Gas Hazards
- Mobile equipment
- Moving and Rotating equipment (Rolls, conveyors, shears, etc).
- Process Hazards such as cobbles, strip breaks, etc.

Based on the author's experience on these types of outages, the most common injuries are hand related (pinch points, cuts, contusions, crushing) related to equipment rigging and setting, slips/trips/falls related to greasy / oily areas and tripping hazards and lastly, eye injuries related to foreign bodies in eyes from demolition or dusty areas.

Typical mitigation strategies for these types of risks are listed below:

- **Hand Injuries**: Use of "No hands-on lifts" via no touch tools and tag lines, proper gloves and body/hand positioning.
- **Slips/ Trips / Falls**: Heavy emphasis on housekeeping, designated walkways, use of "cord trees", cleaning of greasy areas at start of outage, use of speedy dry if there are spills.
- **Eye Injuries**: Use of appropriate PPE including face shields or foam lined glasses, not standing under or near equipment being cut / demolished.

ENERGY ISOLATION PLAN

In addition to the above hazards, a detailed lock out / tag out (energy isolation) plan should be developed. For example, some electrical or hydraulic systems may need to be kept live or repowered to move equipment in or out during the shutdown. Some systems have to be brought back online prior to full equipment start-up to allow for equipment testing and cold commissioning activities. The lockout and isolation plan must be developed in conjunction with both the construction and commissioning teams and plant operations and maintenance.

FIRE PREVENTION

Fire prevention is another key priority when facilitating projects around operating areas where grease, oils, process gases, etc., can be present. Therefore, a suitable fire prevention plan needs to be developed and implemented. Plant emergency services should be engaged in the planning phases for their input and to be aware of the work scope and risks. This allows for proper planning and verification of necessary fire prevention equipment. Finally, if there are fire prevention systems that need taken out of service, the plant protection team must be notified.

ENGINEERING

Having the engineering fully completed and to the correct level of detail is critical to the success of the outage. This will avoid delays resulting from questions during installation or rework due to poor engineering. The engineering should be complete well prior to the start of the outage to allow for detailed construction planning to take place.

In addition, consider the following best practices for completing the engineering

- Conduct sufficient reviews with operations and maintenance to ensure they agree with the designs, and they are functional. This includes participation in design reviews and facilitated document and drawing reviews.
- Field verification of existing equipment locations and tie points or connection points for the new equipment must be conducted. Since there have likely been field modifications since the equipment was installed, a physical verification of dimensions, location and condition should be conducted. While laser scanning and drawings can be good tools during the development phase, field verification should take place in detailed engineering.
- Establish a process for Requests for Information (RFIs) from contractors with a timely response. Consider on the outage, if a particular discipline will likely have many questions, it likely makes sense to have a field engineer present for an immediate response.
- A detailed Quality Assurance plan with checklists showing construction tasks complete with QA checks should be developed prior to the outage and reviewed in the detailed planning phases. The construction managers and field engineers can validate that all construction tasks have been completed to the required standard.
- A final item that is often forgotten but ties to the above point is a surveying plan. Often, as equipment is being set, there are checks that need to be made and validated before moving onto the next step such as grouting. At each survey point, there should be a documented check and sign-off that the equipment has been set into place properly.

CONTRACTING STRATEGY

Contractor selection and contracting strategy plays a critical part in achieving a successful outage. Selecting the appropriate contractors, number of contractors, engaging them at the right time in the project and various contract types are all considerations when developing challenging brownfield projects.

Contracting strategies need to account for engineering status, facility access/interferences, integrating multiple work scopes between project and maintenance work, labor availability and more. This often requires early contracting to allow for pre-outage work and constructability planning. In most cases, the talent to develop, manage and execute successful complex brownfield outages are found within contractor companies with several years, if not decades of experience. Having them involved early can also have a positive influence on designing for pre-assembly, modularization considering the lifting or rigging equipment available. For example, installing a roller table or mill housing require significant lifting / setting techniques that are often only known to specialized contractors. Having these contractors involved early can have a positive influence on designing for pre-assembly, modularization considering the lifting or rigging equipment available.

Another key aspect to consider is the number of contracts and contractor interactions. Typically, these outages require multiple crafts to be concurrently working in the same area or adjacent areas. In other words, it is not a typical greenfield project where a contractor fully completes their work in a particular area and then hands over to the next contractor. There are also shared resources such as scaffolding, mobile/overhead cranes, fire watch, vacuum trucks, that are shared by multiple contractors. Therefore, if multiple contractors will be involved in the outage, the owner must provide a suitably sized and experienced construction management team who will be responsible for coordinating these contractors; for example, prioritizing access into work areas. Another option is to have one of the contractors assume the role of General Contractor (with other contractors sub-contracted to them); however, this contractor must have suitable experience with managing multiple crafts in tight areas on a fast-paced outage. The contractors selected should be familiar with, and capable of working within the plant. If they are new to the plant, then the owner must appoint an individual whose role is to coordinate with plant personnel, provide plant contacts, get work permits signed and know the area utilities.

Lastly the type of contract structure must be considered. While lump sum can be tempting, it's often not the right solution for this type of work where there can be unplanned delays and high potential for interferences. Alternate contract strategies include a fixed fee reimbursable type, where contractors are incentivized to complete their work safety and on time through a fixed management fee, but labor and materials are reimbursable.

SCHEDULE DEVELOPMENT AND MANAGEMENT

Developing an appropriately detailed schedule with input from all key stakeholders including logic ties, then managing the schedule through the outage is critical. This allows for the project team to understand progress and be able to react in a timely manner to delays understanding their impact to the critical path. This gives the project team the information to make correct decisions and apply resources to tasks needed to maintain the schedule.

Schedule Development

Schedule development for this type of outage is probably the most critical activity. There are a number of factors to consider that are discussed below:

- Initial schedule development will often be based on reference projects, high level planning and the experience of the team. Although this will initially set the outage duration, the team must keep in mind that as the schedule is further developed, the outage duration may change. They must also communicate this to senior management who can have unrealistic expectations for shutdowns. If the outage duration is not feasible for production reasons, then it may mean the project is not feasible and should be stopped before too much cost is sunk.
- Unless the owner or EPCM firm has personnel who have been involved in these types of outages and have a very good understanding of task durations and interdependencies, it is recommended to get an installation contractor engaged early to assist with schedule development and constructability planning.
- Once the execution contractor is brought on board, they need to take ownership of the construction tasks in the pre-outage and outage schedules. An initial schedule review should be held with the contractor to determine which tasks can be moved to pre-outage. After this review is completed, the contractor should spend several weeks developing their detailed resourced loaded outage schedule. Any short shutdowns required for pre-outage work should be identified and then approved by plant management.
- Plant personnel also need to be involved in the development and review of the schedule for several reasons; they understand the equipment, they may have their own scopes of work that could impact the project schedule, they understand facility logistics and crane access and may have executed similar work in the past and thus will have a good idea of durations. They should provide the task durations for the shutdown, isolation, lock out, cleaning and removal of operating equipment from the area before the contractors move in.

- As the schedule is developed and if there is a change in the outage duration, whether an increase or decrease, this must be communicated to senior management. There should not be an unrealistic expectation for an outage duration pushed by management. However, a stretch target is not a bad thing. If the outage duration is not achievable from the start and extends there will be a higher cost impact than if it's planned for an achievable, but slightly longer duration. Product inventories can be built up by the plant to maintain production at downstream units, and craft and commissioning resources will be available at the right time (not waiting for work to finish or not having to leave the site for other commitments).
- Commissioning is another area that is often left too late and not sufficiently detailed. Given the criticality of having a vertical start-up, a significant amount of effort should be put into developing a realistic commissioning and start-up plan.
- Ensure all critical equipment and materials are included on the integrated project schedule; the outage should not start without all critical equipment on site.
- The schedule must have logic ties between engineering, procurement (equipment deliveries and contracts), construction and commissioning tasks. The schedule should be resource loaded and the critical path must be identified along with float for each task.
- The schedule should also include resources required to support installation tasks, for example cranes, scaffolding, fire watch, etc., to ensure the correct amount are on site for the outage.
- Tasks with verification such as surveying, need to be included along with contingency for levelling adjustments based on the survey results. The same principle applies for hydraulic flushing, one can't assume the first test will results in the correct particle size and flushing can be stopped.

"MOCK OUTAGE"

A detailed outage planning session, which our team called a "mock outage" should be conducted approximately one month prior to the outage, AFTER the integrated project outage schedule has been completed but not so close to the outage start that any changes / concerns cannot be addressed because there is insufficient time. It's recommended that this "Mock Outage" be held off site to eliminate distractions, especially for plant personnel.

Participants should include (if applicable for the project):

- Project manager
- Project scheduler
- Project Construction Manager
- Plant representatives- operating, maintenance, safety
- OEM Team(s) – Site Manager, Engineers, Commissioning Team
- Installation Engineering Team – Site Manager and Field Engineers (all required disciplines)
- Construction Team – Project Manager, Superintendent, Scheduler, Safety, General Foreman (from each trade)
- Scaffolding
- Surveyors
- Others as required.

A sample "Mock Outage" agenda is shown below:

- Kickoff
    - The project manager goes over the meeting agenda, sets expectations for the meeting, general housekeeping – makes it clear that it's an open forum where all comments/concerns are welcome
    - The project manager (or someone from upper management from the facility, if available) discusses the importance of the work and outage durations to the plant/corporation – big picture view
    - Safety first – it must be understood that even though outage/work is critical, safety will be the priority. If there is an issue, upper management will support stopping the job – no job is more important than someone's life
    - Introductions of all personnel present
- Schedule Review
    - The project scheduler leads, the project manager facilitates
    - Schedule is displayed with projector or TV
    - Step through schedule – identify interdependencies, interferences, conflicts, contingencies
    - Record risks and mitigation plans
    - Project manager to challenge task durations
    - Summarize key milestones for each shift
    - Ensure adequate time included for commissioning and start-up activities

- Risk Register/Lessons Learned
    - Summary of risks identified during the session and mitigation plans
    - Discussion of lessons learned from previous/similar outages
    - Action/follow-up items

After the completion of the mock outage and any required schedule updates, all stakeholders should agree on the final duration for the outage; at this point the outage schedule is baselined.

Schedule Management

Schedule management on the outage is also critical; consider progress monitoring and tracking will be handled and the frequency of schedule reviews. Many of these factors will depend on the type of work and duration of the outage. Typically, schedule updates will be done at least daily or once per shift and the schedule is reviewed at the daily (or shift) progress meetings. Schedule updates can be made by the contractors and provided to the outage scheduler, or the outage scheduler can get direct updates from contractor craft leads and make the updates to the schedule. Bottom line is that the updates must provide the outage management team in the information needed to make key decisions in a timely manner.

SITE ACCESS AND LOGISTICS

Ensuring efficient and safe access to the facility will allow for craft personnel to spend more time in the field and be more productive. This aspect is often overlooked, consider that craft personnel working a 12-hour shift have to spend 30 minutes to get in and out of a facility, their level of fatigue and frustration is increased. Most plants have gates for employee access that contractors can use which works during regular operations and short maintenance turns. However, for large outages requiring significant craft personnel, these entrances become overloaded resulting in line-ups and delays. Therefore, well prior to the outage, it is recommended that the project team and plant security establish a plan for “outage” contractor access. For example, temporary gates or portable turn styles can be used and additional security personnel can be added to speed up the pass control process.

Contractor parking is another aspect that’s often overlooked. Consider from a safety perspective that there have been injuries and fatalities in contractor parking lots as a result of crowding, poor lighting, un-even surfaces. Therefore, develop a plan for contractors to park safely and efficiently which may results in bussing them to gate or the work site.

The location of contractor trailers is another consideration; they should be as close to the job site as possible without interfering with plant operations or blocking access for mobile equipment. Minimizing the distance to the job site will allow for more efficient use of contractor craft personnel (more tool time, less walking time).

While the above efforts can appear difficult to justify financially, there is a clear benefit to the morale and attitude of the craft personnel. They will recognize the effort to make their workday more efficient and will appreciate the effort; the authors received many compliments about the plant access, parking and bussing that was established for the outages they were involved with. There is also the benefit of reduced safety incidents, not only during parking and travel to jobsite, but also during construction due to improved attitude and reduced fatigue of craft personnel.

Another important planning tool is the development of a “plot plan” showing lay down of equipment and materials, locations of lock boxes, locations of contractor job boxes, space required for mobile equipment to bring in and remove equipment, mobile crane placement, etc. This helps eliminate contractors “squabbling” over who gets rights to an area and also eliminates logistical delays where entrances and exits are inadvertently blocked.

The use of “area information boards” is highly recommended. These boards contain the information listed shown in the schematic below and are located in a safe location adjacent to the work area. These can be made of wood and re-used again for subsequent outages.

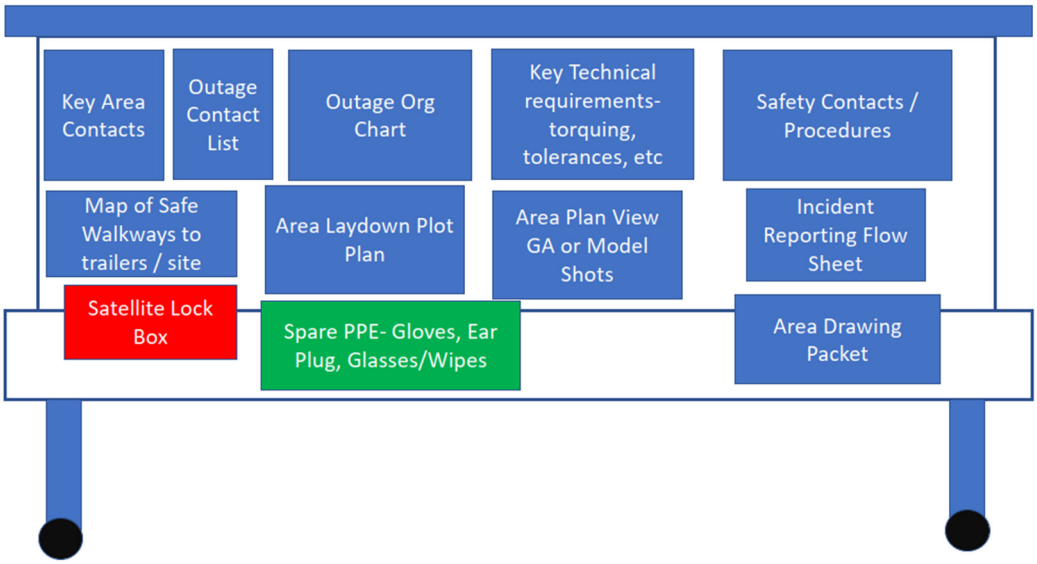

Figure 1. Site information board example.

EQUIPMENT READINESS

Another critical aspect is having the equipment completely ready for installation; verifying that the equipment is in good shape, all there and ready to start-up after installation. This means:

- Ensuring all equipment (including small parts) is on site and not damaged. Therefore, conducting an Open Package Inspection (OPI) with enough time to replace or repair missing equipment or components. After the OPI, the equipment should be stored in a secure location to prevent any parts or components from going missing like being used as "spare parts". This equipment also needs to be protected from the elements.
- Ensuring all required spare parts are on site and readily available during commissioning; they need to be easily accessible by the commissioning team and not locked up in a shipping container or the plant storeroom that can only be accessed on daylight turn.
- Off-line pre-assembly of the equipment can be a good technique to allow the crews that will be installing it to experience how it is assembled and speed up installation. This may require some temporary supports for example but is usually well worth it when it comes to reducing the outage installation time.
- Factory Acceptance Tests (FATs) on main equipment should be completed per the paper "Best Practices for conducting Factory Acceptance Tests on Major Capital Projects" by Neil Tannyan, George Granger, Matthew Marcus and Nicole Sitler presented at AIST Tech 2021.
- With regards to automation equipment and upgrades, Factory Acceptance Testing and "Shadowing" should be completed to minimize the risk of problems during start-up.

OUTAGE MANAGEMENT

Organization

An outage organization chart should be developed along with clearly defined roles and responsibilities for key personnel on the outage management team. An overall Outage Manager (Owner) who can see the big picture and can make decisions regarding priorities should be appointed. If one area slips behind, the outage manager can allocate resources from other areas to catch up on critical path tasks. The outage should be broken down into geographically manageable "areas". An area manager or area owner should be appointed who is responsible for all activities within that area.

Well prior to the outage, the availability of key personnel from all stakeholders should be confirmed. Key personnel from the project team, plant, contractors, OEMs should all be identified on the outage organization chart. From there, an outage contact list should be developed and distributed to all personnel involved in the outage to avoid communication related delays.

Meetings, Reporting and Handover

Developing a plan for meetings, handover and reporting is also important. Too many meetings with too many people takes away valuable field time; however, no meetings or communication can lead to confusion and delays in the field so a good balance must be achieved. Therefore, a meeting plan should be developed including meeting times, agendas, participants and locations of the meetings. Key information should also be communicated to all personnel who are not at the meetings. It is recommended that a succinct written shift report be prepared to ensure follow-up items are not missed during handover. Also, a daily report should be used to memorialize the outage and support a Lessons Learned exercise. Lastly, a plan for reporting to upper management should be developed that updates the outage status so plant management can ready for start-up and also consider impacts to other production units within the facility.

Operations and Commissioning Readiness

Developing a plan for Operational Readiness to allow the operators to operate and maintain the new equipment is critical to avoid delays on start-up. This topic was already discussed in detail in the previously published paper "Planning for Success: Operational Readiness Planning and Change Management for Major Capital Projects" by Neil Tannyan, Thomas Ruffner and Rifat Jabbar presented at AIST Tech 2021.

RISK AND CONTINGENCY

This last section discusses approaches to managing risk and planning for contingencies when developing the outage plan. As much as the team hopes tasks on the outage will proceed exactly as planned, it is rare, especially in brownfield sites that this happens. So, there must be back-up plans and contingencies in place should problems occur in the field during the outage. Contingencies should be considered when developing the project schedule and applied based on the level of risk identified.

One of the most basic starting points it the use of a project risk register focusing on outage risks. Risks that are considered "high" with potential to significantly extend the outage should be addressed with mitigation plans. Monthly reviews and updating of the risk register should take place and with the frequency increasing to weekly prior to the outage. During the mock outage, risks should be discussed for each task and the team should consider adding contingency to either the overall outage schedule, or individual tasks. As an example, consider having additional spare parts and additional critical construction equipment like welders, cranes and flushing units either at site or nearby so in case of a failure then it can be easily replaced.

Lastly if the outage is heavily dependent on people for an automation type project, consider bringing additional people to the site for the outage in the initial team gets worn out. It's not uncommon for persons to work very long shifts when troubleshooting; therefore, they will be required to be off site and rest, so a back-up person(s) is required. In addition, a new set of eyes can help spot a problem that others have missed. If the owner has resources at another facility that can be "lent" for the outage, then they can return quickly to their home facility if things go well. The author saw this approach used very well on a project several years ago where several persons were "loaned" from another facility that had similar operating equipment to assist with commissioning and start-up activities.

CONCLUSION

Outage planning should be like a dress rehearsal for a play. All involved should know their tasks and steps to take. But given the tricky nature of brownfield sites with many "hidden" surprises, the team must plan for unknowns with contingencies, alternate plans and solutions. Having the right people and conducting the appropriate level of detailed planning are the two major factors to being successful.

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DISCLAIMER